

Evolution of root canal sealers and its impact on success of endodontics.

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Abstract: Root canal sealers are widely being used in endodontic practice with each one having own merits as well as demerits. Attainment of ideal root canal treatment comprises various essential factors but ultimately depending upon the sealing of the root canal. Hence sealers have an important role in successful endodontics. The reason is to review various root canal sealers and its impact to get absolute rid of microbial entity and prevent any future predilection of re-infection. Although gutta-percha has been the standard obturating material, it does not reinforce endodontically treated roots owing to its inability to achieve an impervious seal along the dentinal walls of the root canal. There is silicone-based sealers like Roekoseal automix and the most recent GuttaFlow have some affirmative results on biocompatibility and solubility as compared to other sealers. The main aim of this article is to review the literature on endodontic sealers and to analyse the recent advancements. The degree of endodontic success is directly proportional to a clinician's knowledge of the root canal anatomy and the techniques selected while performing treatment. Properly performed endodontic therapy is the cornerstone of restorative and reconstructive dentistry.

Keywords: Root canal therapy, Root canal sealer, Adhesive properties, Bio-compatibility, Antimicrobial efficacy.

Introduction:

Filling of root canal space is done using two main components: A core filling material and root canal sealer. The most favourable bio-compatible filling material that can be used to fill the space is Gutta Percha. This material alone is not enough to produce three-dimensional seal of the root Canal system, as it only adapts to the adjacent dentinal walls. However, root canal sealer is necessary to fill the Accessory canals, minor discrepancies and irregularities. The three-dimensional sealing of the entire root canal space with a bio-compatible filling material is a challenging task to be achieved for the success of endodontic treatment.

Ideally, Root canal sealer should be capable of creating an effective bond between the core material and the dentine thus preventing leakage. It should also be non-toxic and must have a positive effect on the healing of periapical lesions. [1]

Although predictable clinical results have been reported with the use of these nonbonding root canal sealers, there has been a continuous quest for alternative sealers. [2]

It is a well-known fact that three dimensional impervious obturation of the root canal system is of prime clinical importance for the long-term success of endodontic treatment. [3]

Wide Variety of endodontic sealers are available commercially and they are divided into different groups. [4] This review article attempts to compile information on various new generation root canal sealers which are advocated to be superior to their contemporary counterparts and also compare their properties.

Sealers:

The sealers are responsible for the main functions of the final root filling: sealing off the root canal system, entombment of remaining bacteria and the filling of irregularities in the root canal. [5] There are various chemical formulations which serves as bases for root canal sealers.

Classification of Root Canal Sealers:**Ingle Classified Root canal sealers based on its chemical composition;**

- 1) Calcium hydroxide containing cements.
- 2) Zinc oxide-eugenol based cements.
- 3) Glass Ionomer based cements.
- 4) Resin based cements.
- 5) Experimental Sealers.

A. Clark classified Root canal sealers into:

- 1) Non-absorbable.
- 2) Absorbable.

Properties of an Ideal Root Canal Sealer:**The following requirements must be met by an ideal root canal sealing material; According to Grossman (1982)**

1. It should be tacky to provide good adhesion.
2. It should make a hermetic seal.
3. It should be radiopaque.
4. The powder particles should be fine.
5. It should not shrink upon setting.
6. It should not discolour tooth structure.
7. It should be bacteriostatic.
8. It should slowly set.
9. It should be insoluble in the tissue fluids.
10. It should be very well tolerated by the periapical tissue.
11. It should be usually soluble in common solvents if it is necessary to remove the root canal filling.

Functions of root canal sealers:

- 1) As a binding agent between the filling material and the dentin walls.
- 2) As a lubricant and gives radiopacity.
- 3) As Antimicrobial agent.
- 4) Helps in filling the discrepancies between the filling material and the dentin walls.

The Concept of Monoblock

The term Monoblock literally meaning a single unit. Franklin R. Tay first described the concept of monoblock in endodontics. A monoblock is a single unit which is gap free and is divided into root filling material along with post and core. [6] It is usually creating a mechanically homogeneous unit with root dentin. Monoblock units can be created in a root canal system by some adhesive root canal sealers such as RealSeal, EndoREZ, MetaSEAL, Epiphany along with bondable root filling material.

MONOBLOCK	OBTURATION
Primary	MTA, NEC, CEM
Secondary	Conventional Resilon, Epiphany, Endorez, Real seal/Metaseal.
Tertiary	GP plus bonding + Resin sealer

Primary Monoblock

It has only one interface that extends circumferentially between the material and the root canal wall. Some examples of primary Monoblock includes Hydron, Mineral trioxide aggregate, Poly ethylene fibre pose core system and Bio-gutta. During 1970's Hydron technologies introduced a poly HEMA containing Root filling material which is named as Hydron. [7] These materials had very good properties which include Non-irritating nature, Easy to use, good adaptation to walls, and also ability to calcify in case of extrusion. However, in 1980, Clinical and laboratory findings showed that this hydron filled root canals exhibited extensive leakage. [8] The major drawback includes lack of sufficient strength and stiffness this led to the development of Secondary monoblocks.

Secondary Monoblock

In this type two circumferential interfaces are present, one between the cement and core material and other between the cement and dentin. It means root canals are obturated with gutta percha, in which one interface is between Gutta Percha point and sealer and the other one between the sealer and root canal wall. The materials that constitute Monoblock should have ability to bond strongly and mutually to one another, as well as to the substrate with which the monoblock is intended to reinforce and must have modulus of elasticity that are similar to the substrate. [9] Modulus of gutta percha points (Lca. 80 Mpa) is 175-230 times lower than that of dentin, making them too plastic to reinforce roots after endodontic therapy. Therefore, in 2004 advent of bondable root filling

materials were launched as alternatives to conventional gutta-percha as obturating materials. Examples of Secondary Monoblock includes Resilon based systems, Fibre re-inforced posts.

Tertiary Monoblock:

These systems have an additional third circumferential interface between the bonding substrate and the abutment material. [10] Leakage and morphological seal of system is mediocre.

Some examples of Tertiary Monoblock system includes Endorez, Fibre posts + external silane. Polymerization shrinkage of the methacrylate-based sealer is present. Sealer bonds weakly to the pre-polymerized proprietary coating-absence of oxygen inhibition layer. Since the external proprietary resin coating is uneven there can be partial detachment.

ROOT CANAL SEALERS BRAND NAME:

- 1) Zinc Oxide Eugenol based sealers - *Roth sealer, Kerr PCS, Procoseal, Endomethasone.*
- 2) Resin based sealers - *AH Plus, AH 26, Epiphany, Diaket.*
- 3) Glass ionomer-based sealers – *Ketac Endo, Espe,*
- 4) MTA based sealers - *MTA fillapex, Endo-CPM-Sealer, MTA Obtura.*
- 5) Calcium-hydroxide based sealers – *Sealapex, Apexit*

Conventional Types of Endodontic Sealers:

Zinc-oxide-eugenol-based sealers:

Zinc-oxide-eugenol materials have been developed in 1931 by Rickert. These sealers have some antibacterial activity of their own, but will also exhibit some toxicity when placed directly on vital tissues. [11] Zinc oxide eugenol sealers has two components a powder component and the liquid component. The powder component consists of Zinc oxide (34-41.2%), Precipitated silver (25-30%), Oleo resins (16-30%), and Thymol iodine (11-12%). The liquid component eugenol consists of (Oil cloves – 78-80%). The main advantage of ZOE includes, excellent lubricating properties, working time more than 30 minutes, usually germicidal, it has greater bulk than any other sealer as it is ideal for condensation techniques. The main disadvantage is irritation, Reduced absorption rate, staining of the tooth and rapid setting time in heat or humidity. Usually an acid-base reaction takes place with the formation of zinc eugenolate chelate forming a reaction. [12] The material of choice is zinc oxide eugenol sealer because it has good ability to seal against microorganisms. To affect a good seal, proper manipulation of this material is very important. It should be done with apical pressure from the centre of the cavity outwards or it may pull away from the margin. It is highly durable When mixed to a high powder and liquid ratio. The only disadvantage of using zinc oxide eugenol bases sealer is with composite resins it is incompatible. Prototypes are Rickert's sealer, commercial in the form of Kerr Pulp Canal Sealer, and Grossman's sealer, which has several commercial variants, such as Roth sealer and ProcoSol.

Resin-based sealers:

Recently methacrylate resin sealers follow the concept of Monoblock. In this type the adhesion of sealer takes place between thermoplastic polymer cone and the dentin walls of the root canal. An ideal property of root canal sealer includes good tissue compatibility and a lasting 3D seal of the root canal. [13] Success of the sealer depends upon dimensional stability like shrinkage, expansion and solubility as well as adhesion to both dentin and applied cones. It must also possess good radio opacity. Resin based sealers are usually made up of an epoxy resin. It is a glue in which the base is bisphenol A-epoxy and hexamethylene tetramine as catalyst. It also contains 60 % of bismuth oxide for radiographic contrast.

Some of the resin-based sealers include:

RoekoSeal, GuttaFlow, Diaket, AH26, AH Plus, EndoRez, Epiphany, FibreFill, Kerr Pulp Canal Sealer.

The main advantage of AH-26 is it set even under water as it is not sensitive to water. It has very good adhesive property, good flow, antibacterial as well as low toxicity which is well tolerated by periapical tissues. The setting time is usually 36 to 48 hours at body temperature, while it takes 7 days to get set in room temperature. Compared with zinc oxide-eugenol sealers, methacrylate-based resin sealers were found to be more effective in sealing. [14] Swiss manufactures of AH-26 recommend that mixed AH-26 must be warmed on glass slab over alcohol flame which makes it less viscous. AH-26 is usually sold as Thermaseal. Even though the AH-26 had good properties, due to the disadvantage of formaldehyde release, extended setting time and staining, the producer of AH-26 set out to develop an improved product which is named as AH PLUS. They retained epoxy resin but added new amines to maintain natural colour of the tooth. It was the material of choice due to its shade and colour stability as the aesthetic demands are high. [15] AH plus come in paste-paste system, Paste A consists of epoxy resin, calcium tungstate, zirconium oxide, silica, iron oxide. Whereas, Paste B consists of Adamantane amine-N, N-Dibenzyl-5-oxanonane-diamine, 1,9, TCD-diamine, calcium tungstate, zirconium oxide and silica-silicone oil. AH PLUS has working time of 4 hours and setting time of 8 hours. When compared to AH-26 this has half the thickness and half the solubility. It may be removed from the canal if necessary. In a study it was said that AH PLUS had less toxicity when compared to AH-26. It is easy to mix and has excellent long term dimensional stability and sealing properties.

Durarte et al in 2003 suggested the addition of 5% of calcium hydroxide so it leads to low viscous material as well as more alkaline Ph and calcium release. This higher alkalinity and enhanced calcium release leads to improved biological and microbial behaviour. AH PLUS is sold world wide as Thermaseal ply by Dens ply International.

Urethane Dimethacrylate base sealers are the Resilon or Epiphany manufactured by Pentron Clinical Technologies. Example of this includes Realseal and SybronEndo. It is developed to replace gutta percha as well as traditional sealers for root canal treatment. It usually self-cures in 25 minutes as it comes with self-etch prime. The disadvantage include technique sensitive as the sodium hypochlorite may negatively affect the bond strength, hence final irrigation must be done using EDTA and sterile water or chlorhexidine. After obturation the coronal surface may be light cured for 40 seconds to create coronal seal. The Resilon/Epiphany system is reported to establish an immediate coronal seal after light curing of the dual-cured sealer at the canal orifices. [16]

On comparing the AH plus and Sealapex, over time both showed similar leakage but AHplus was slightly better when compared to sealapex.

In a study, the time period for bacteria to penetrate through the obturated root canal to the root apex using *Endodontalis faecalis* as a microbial tracer between Ketac-Endo and AH-Plus was done there was no statistical difference between both at a period of 30 days. Another results showed that epoxy resin root canal sealer was found to be more adaptable to the root canal wall and filling material than a calcium hydroxide sealer when bacterial coronal leakage was studied. [17]

In a in vitro study, two sealers AH26 and AH plus along with gutta-percha were examined for leakage of bacteria. There was no statistically significant difference in leakage of bacteria between two sealers. [18] On conclusion, overall AH-Plus demonstrated better diffusion into lateral accessory canals when compared to AH-26, as both AH26 and AH Plus root canal sealers provide tight three-dimensional seal by adhering to the tube walls. [19]

Although so many studies have been published about sealing and adhesion properties of resin-based sealer, over all AH series has been successful in resin-based sealers. The prototype of Resin-based sealers has bis-phenol resin using methenamine for polymerization. Resorcin formaldehyde type is variant of the phenol-formaldehyde and possesses strong antibacterial property. Compared with zinc oxide-eugenol sealers, methacrylate-based resin sealers were found to be more effective in sealing. [20]

Glass-ionomer-based sealers:

In 1971, Glass ionomer was introduced in the field of dentistry by Wilson and Kent, initially as a restorative material. Later in 1991, [21] Glass ionomer was introduced as root canal sealer branded as Keto-Endo, ESPE. The Glass ionomer sealers usually possess the properties of hydroxyapatite adhesiveness and constant fluoride liberation which is anti-cariogenic in nature. Glass ionomer sealers have good chemical bonding and physical characteristics when bonding to dentine and is biocompatible and to show good adhesion to dentin. In a study it was shown that Ketac-Endo has very low apical microleakage when used as thin layer. [22] Main advantages includes Ease of manipulation, best bond to dentin, Fewest voids, Lower surface tensions, and best flow. Major concern in glass ionomer sealer is there will be a problem of removal in the event of retreatment since there is no known solvent available for it.

MTA based sealers:

MTA based sealers have been introduced during 1903 by Dr. torabinejad, USA. It is usually available in grey or white colour. The composition of Grey colour sealer includes Tricalcium silicate, Dicalcium silicate, Tetra calcium aluminoferrite. White component is same as grey one only with absence of Tetracalcium alumino-ferrite. Setting time is about 2 hours and 45 minutes and has Ph of 12.5 which is alkaline in nature. [23] It sets extensively in moist environment. It is made up of calcium silicate based material. It is usually used as apexification material. In orthograde obturation it is used in case of open apices. These MTA based sealers are highly Biocompatible and are anti-microbial. Only disadvantage is the tooth cannot be retreated when obturated using mineral trioxide aggregate sealer. Even though it has disadvantage these alkaline biomaterial have gained high acceptance in the field of endodontics due to their good physical-chemical and biological properties. Ideally MTA is carried out into canal using a carrier and plugged into a space. Over time biomineralization occurs there by adhering to root dentin. With regard to physical properties the compressive elastic modulus of cement increases up to 15,000 Mpa, after 14 days. [24] Mineral trioxide aggregate is theoretically capable of increasing the root strength and has high fracture resistance. Example of MTA based sealers include: MTA fillapex, Endo-CPM-Sealer, MTA Obtura.

Calcium hydroxide-based root canal sealers;

Calcium hydroxide-based root canal sealers are usually insoluble, radio-opaque which are being used in root canal as a root canal sealer in combination with gutta percha points. It has excellent physical and biological properties. The working time for this type is approximately 3 hours, where in the addition of water reduces the setting of it. The composition of Calcium Hydroxide base root sealer includes Calcium salts(Hydroxide), Oxide, (phosphate), Hydrogenized colophony, disalicylate and bismuth salt. [25] An example of calcium hydroxide-based sealers are Apexit plus, Sealapex have a base and the catalyst. The base contains Zinc oxide, calcium hydroxide, butyl benzene, sulphonamide, zinc stearate. Catalyst consists of Barium sulphate, titanium-di-oxide as radioopacifiers and isobutyl salicylate. This sealer takes three weeks for final set in 100% humidity. It never sets in dry atmosphere. Later alternatives have been manufactured which are similar to seal apex, which include LIFE, Vitapex, Dentalis. The setting time of Apexit plus can be very quick if the canals are properly dried. Apexit plus may remain soft several days depending on humidity present. Ideal setting time of Apexit plus is between two to five hours. In very dry canals it can be more than ten hours. [26] The main concern is that insertion of endodontic post or apicectomy should not be done 24 hours following the obturation. Apexit differs from Apexit plus as it is supplied in a more convenient form and has more hydrophilic formulation.

RECENT ENDODONTIC SEALERS:**ProRoot Endo Sealer**

It is a calcium silicate-based root canal sealer. It is intended to be utilized with a root filling material in either the cold horizontal or carrier-based filling systems. It has powder segment which is tricalcium silicate and dicalcium silicate, with calcium sulphate as a setting retardant, bismuth oxide as a radiopacifier and a little measure of tricalcium aluminate. The fluid segment comprises of a thick viscous solution of water dissolvable polymer. Like other tricalcium silicate and dicalcium silicate-containing biomaterials, the sealer produces calcium hydroxide when reacted with water. [27]

Herbal sealer (bio sealer)

It is the root canal sealer based on copaifera multijuga oil-resin. Trees belonging to the genus copaifera are dispensed around northern south the united states, particularly inside the amazon rainforest. It is one of the most famous and promising phytomedicines used in brazil. The powder is composed of zinc oxide, calcium hydroxide, bismuth sub carbonate, herbal resin (rosin) and borax, and the liquid is purified copaifera multijuga oil-resin. [28] Nanoseal plus root canal sealer has high incidence for root canal failure and is due to the incapacity to seal the accent canal in maximum instances. It is made up of calcium phosphate hydroxyapatite nanoparticles range from 40-60 nm. The rod-shaped nanoparticles can penetrate the dentinal tubules & enter accent canals to ensure that every one the areas are correctly sealed. [29]

EVALUATION AND COMPARISON OF VARIOUS ENDODONTIC SEALERS

Various evaluation parameters for testing endodontic sealers have been introduced. They include technologic tests standardized by the ADA/ANSI in United States, and the ISO internationally. These technological tests include flow, working time, setting time, radio opacity, solubility and dimensional change following setting. [30]. In bacterial leakage tests were superior to gutta percha and various other sealers.

CONCLUSION:

The qualities of different sealers should be considered before obturating the root canal. The efficiency of the sealer and the anatomy of the root canal influence the success and survival rates of the treatment. Traditional, zinc-oxide eugenol and epoxy resin sealers have stood the test of time and perform well clinically and in laboratory tests. It is exciting to see new formulas and concepts for root filling emerge with an obvious potential for improvement. It must be remembered that clinical studies have a high degree of variability because of the multitude of factors affecting outcome. Therefore, it may be difficult to document improved treatment results that are statistically significant in comparison with conventional materials of reference.

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